Electronic Version
Stylesheet Version v1.1.1

Description

DASH CONTROL VALVE WITH TWO STEP FUNCTION FOR PARK RELEASE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation-in-part of pending U.S. Application No. 09/852,232, filed May 8, 2001.

BACKGROUND OF INVENTION

[0002] The invention relates to the art of vehicle braking systems and finds particular application in heavy trucks, tractors, and buses. The invention will be described in relation to an air pressure braking system of a tractor-trailer truck system. It will be appreciated, however, that the invention is also amenable to other applications (e.g., other braking systems such as those of other kinds of vehicles and those based on other technologies such as hydraulic or electronic braking systems).

[0003] U.S. Patent No. 4,844,553 to Bliss and U.S. Patent No. 4,330,157, which are both incorporated herein by reference, disclose control valve arrangements for use in a

braking system. The valve arrangements include a pair of valve actuators or plungers that are operated by a vehicle operator. One of the actuators controls communication between an air pressure source and a tractor parking/emergency brake system. The tractor parking/emergency brake system includes spring brakes that are actuated to resist wheel rotation. A force of an included spring or set of springs in the spring brakes urges a braking member against the wheel. During vehicle operation, air pressure is applied against a piston that is associated with the springs. The force applied against the piston counteracts the force of the springs thereby releasing the spring brake and allowing the wheels of the vehicle to rotate. The other actuator controls communication between the pressure source and service brakes of a trailer.

[0004] In addition to providing for manual application and release of the parking/emergency brakes, the disclosed valve arrangements also provide for the automatic application of brakes should the source or actuation pressure fall below a threshold. That is to say, the first actuator is forced into a pressure exhaust position by internal springs if the source pressure drops below a first threshold. Similarly the other actuator is forced into a pressure exhaust

position if the pressure drops below a second threshold. This provides for the trailer brakes and the tractor brakes to be applied in an appropriate order should a malfunction or leak occur in the braking system.

[0005] One feature the prior art valve arrangements do not provide is an assurance that a vehicle operator has actuated the service brakes before the parking brakes are released. As a result, the vehicle could roll unexpectedly when the operator releases the parking brakes.

[0006] Therefore, a braking system interlock arrangement that requires the service brakes of a vehicle to be engaged before the parking brakes of the vehicle can be disengaged is desired.

[0007] The present invention provides a new and improved apparatus and method which addresses the above-referenced problems.

SUMMARY OF INVENTION

[0008] In one embodiment, a valve assembly for an air pressure system includes an inlet valve, a first control valve, and a second control valve. The inlet valve includes an inlet port, an outlet port and a control port. The inlet valve inlet port communicates with the inlet valve outlet port when the inlet valve control port is above a threshold pressure. The

first control valve includes an inlet port, an outlet port, an exhaust port, and a control member. The first control valve inlet port communicates with the inlet valve outlet port. The first control valve outlet port communicates with one of the first control valve inlet port and the first control valve exhaust port as a function of a position of the first control valve control member. The second control valve includes an inlet port, an outlet port, an exhaust port, and a control member. The second control valve inlet port communicates with the inlet valve outlet port. The second control valve outlet port communicates with one of the second control valve inlet port and the second control valve exhaust port as a function of a position of the second control valve control member.

BRIEF DESCRIPTION OF DRAWINGS

[0009] In the accompanying drawings which are incorporated in and constitute a part of the specification, embodiments of the invention are illustrated, which, together with a general description of the invention given above, and the detailed description given below, serve to exemplify the embodiments of this invention.

[0010] *FIGURE 1* is a schematic diagram illustrating the control logic of a braking system control block operative to re-

quire a two-step brake release process.

[0011] *FIGURES 2A and 2B* are a diagram showing a first valve assembly configured as a braking system control block operative to require a two-step brake release process, the valve assembly being in a first operational state.

[0012] *FIGURES 3A and 3B* are a diagram showing the valve assembly of *FIGURES 2A and 2B* in a second operational state.

[0013] *FIGURES 4A and 4B* are a diagram showing the valve assembly of *FIGURES 2A and 2B* in a third operational state.

[0014] *FIGURES 5A and 5B* are a diagram showing the valve assembly of *FIGURES 2A and 2B* in a fourth operational state.

[0015] *FIGURES 6A and 6B* are a diagram showing the valve assembly of *FIGURES 2A and 2B* in a fifth operational state.

[0016] *FIGURE 7* is a functional diagram of an inlet valve shown in a first operational state.

[0017] *FIGURE 8* is a functional diagram of the inlet valve of *FIGURE 7* in a second operational state.

[0018] *FIGURE 9* is a functional diagram of a third valve assembly configured as a braking system control block operative to require a two-step brake release process.

DETAILED DESCRIPTION

[0019] Referring to *FIGURE 1*, a valve assembly *104* operative to require an operator of a vehicle to apply service brakes

106 of the vehicle before both i) tractor parking or spring brakes *107* and ii) trailer parking or spring brakes *184* can be released includes a control double check valve *108* and an inlet valve *110*. The inlet valve *110* and control double check valve *108* co-operate to form a sensor, system inlet valve, and an interlock device. As will be seen below, the sensor monitors the state of the vehicle braking system. The system inlet valve directs pressure to certain parts of the braking system at appropriate times as determined by the sensor. The interlock latches the sensor and system inlet valve into a permissive or open state when appropriate.

[0020] More particularly, the control double check valve *108* includes a service pressure port *114*, a locking pressure port *116*, and a control pressure outlet *118*. The control double check valve *108* operates to direct system status information to the sensor. For example, the information is in the form of system pressures. The control double check valve *108* directs a greater of pressures applied at the service pressure port *114* and the locking pressure port *116* to the control pressure outlet *118*.

[0021] The inlet valve *110* includes an actuating pressure port *120*, an input or supply pressure input port *122*, and an

output or supply pressure delivery port *124*. Additionally the valve includes a biasing member *126* for urging the inlet valve toward a closed position, thereby blocking air flow to the supply pressure delivery port *124* from the supply pressure input port *122*. The actuating pressure port *120* communicates with the control pressure outlet *118* of the control double check valve *108* through a control check valve output channel *130*. When air pressure delivered to the actuating pressure port *120* exceeds that required to counteract the urging force of the biasing member *126*, the inlet valve is actuated to permit flow and pressure equalization between the input port *122* and delivery port *124*.

[0022] The input port *122* communicates with a supply pressure source through a supply selector double check valve *131* and a supply conduit *132*. The supply conduit *132* connects to the check valve *131* at a selected supply delivery port *134*. The supply selector double check valve *131* includes a primary supply port *136* connected to a primary supply reservoir *140* via a primary supply line *142* and a secondary supply port *138* connected to a secondary supply reservoir *144* via a secondary supply line *146*. The supply selector double check valve *131* directs a higher of

pressures from the primary supply port and the secondary supply port to the selected supply delivery port *134*.

[0023] Typically, the pressurized air is delivered to the supply reservoirs *140* , *144* by one or more pumps or compressors (not shown). The pressurized air is used to actuate various components of the vehicle braking system. For example, the pressurized air is used to drive a piston and counteract the force of the springs thereby releasing the brake pads from engagement with respective wheels (not shown) in the tractor and trailer spring brakes *107* , *184*.

[0024] The control double check valve *108* and the inlet valve *110* work together to provide pressurized air for enabling release of the tractor parking brakes *107* and the trailer parking brakes *184* at appropriate times. When it is inappropriate to release the parking brakes the control double check valve *108* and the inlet valve *110* work together to prevent the delivery of pressurized air to the spring brakes *107, 184*.

[0025] For example, port *114* of the control double check valve *108* communicates with a service brake line *152* to receive pressurized air from a service supply double check valve *153*. The check valve *153* directs, for example, a higher of two pressures delivered from a proportional valve *154* to

the service brake line. Here, the proportional valve *154* is operatively associated with a brake pedal (not shown) of the vehicle. The proportional valve *154* receives pressurized air from a primary service supply conduit *155* and a secondary service supply conduit *156*. The proportional valve *154* proportions the pressures delivered to it. For example, the proportional valve *154* delivers a proportioned primary supply pressure and a proportioned secondary supply pressure to the service supply double check valve *153*. The proportioned pressures depend on the degree of actuation of the proportional valve *154*. For example, if the brake pedal is not actuated at all, then the delivery pressure of the proportional valve *154* is 0 psi. If the brake pedal is partially depressed then a percentage or fraction of the primary and secondary supply pressures are delivered to service supply double check valve *153*. Obviously, various pressures or fractional pressures may be delivered as well. The service supply double check valve *153* then directs one of the supplied pressures to the service brake line *152* to effect braking. When the pressure in the service brake line *152* is higher than a pressure at the locking pressure port *116* the control double check valve operates to deliver the service brake line pressure to

the actuating pressure port *120* of the inlet valve *110*, thereby indicating that degree to which the service brakes are applied to the wheels of the vehicle. When the pressure at the actuating pressure port *120* exceeds a predetermined threshold, for example 25 psi, the inlet valve *110* directs supply pressure from the supply conduit *132*, to the supply delivery port *124* where it enables the tractor and trailer spring brakes *107* , *184*, respectively, to be released once the respective plungers are deactuated as will become more apparent below.

[0026] For example, the supply delivery port *124* is connected to a parking/emergency brake control valve *160* and a trailer parking/emergency brake control valve *1 80* via a first control valve supply conduit *162*.

[0027] The spring brake control valve *160* includes a tractor spring brake supply port *164*, a tractor spring brake exhaust port *166*, and a tractor spring brake delivery port *168*. The spring brake delivery port *168* communicates with the tractor spring brake system *107* via a spring brake pressure line *170*. Additionally, the spring brake pressure line *170* provides spring brake pressure to the locking pressure port *116* of the control check valve. A biasing spring *172* urges the tractor spring brake control

valve toward an exhaust state, wherein any pressure stored in the spring brakes *107* is normally vented via the tractor spring brake exhaust port *166*.

[0028] It is anticipated that in a comparable electrical braking system, energy will not be stored in the braking system. Therefore, in an electrical analog to the exhaust state, the parking brakes would simply be de-powered. However, some designs, such as, for example capacitive and inductive designs may benefit from energy regeneration or dissipation. Therefore in an electrical analog to the exhaust state, the parking brakes may be connected to an energy storage device or a dummy load.

[0029] The trailer air supply valve *180* includes a trailer air supply port *181*, a trailer air exhaust port *182*, and a trailer air delivery port *183*. The delivery port *183* is connected to the trailer air system *184* via a trailer air line *185*. A biasing member or spring *186* urges the trailer air supply valve *180* to an exhaust state position where pressure in the trailer air system *184* is vented to atmosphere *178*. In order to supply air to the trailer systems *184*, the operator must deactuate (e.g., push) a plunger button *187* associated with the trailer air supply valve *180*. Deactuating the plunger directs whatever pressurized air that is present at

the trailer air supply port *181* to the trailer air delivery port *183*. Additionally, pressurized air at the trailer air delivery port *183* is applied to a trailer air supply valve pilot or control port *188*. Pressure at the pilot port *188* holds the trailer air supply valve plunger (not shown) and button *187* in position after the operator releases the plunger button *187*, thereby holding the trailer air supply valve *180* in the trailer system pressurization state. The trailer air supply valve *180* directs pressurized air for releasing brakes of a trailer. Additionally, trailer air pressure is made available to power trailer accessories such as conveyer belts, ramps and lifts. In one embodiment, pressurized air from the trailer air supply valve is delivered to the trailer system through a tractor protection valve. The tractor protection valve serves to isolate the tractor systems from the trailer in the event of an unintentional disconnection.

[0030] As described above, in order to release the tractor parking or spring brakes *107* or the trailer parking or spring brakes *184*, the operator must first apply the service brakes. Additionally, the operator must also deactuate plunger buttons or control switches *174* , *187* associated with the tractor spring brake control valve *160* and the trailer air supply valve *180*, respectively. Deactuating the

plunger buttons *174, 187* positions the control valve *160* in a tractor spring brake pressurization state and the trailer air supply valve *180* in a trailer spring brake pressurization state.

[0031] While in the tractor spring brake pressurization state, the tractor control valve *160* directs pressurized air at the supply port *164* to the delivery port *168*. Additionally, pressurized air at the spring brake delivery port *168* is applied to a tractor spring brake control valve pilot or control port *176*. Pressurized air at the pilot port *176* latches or holds the tractor spring brake control valve in position after the operator releases the plunger button *174*, thereby latching the tractor spring brake control valve *160* in the spring brake pressurization state. Furthermore, system status information, in the form of spring brake pressure, delivered to the locking pressure port *116* of the control double check valve *108* is directed to the actuation port *120* of the inlet valve *110*, thereby locking or latching the inlet valve in a supply pressure delivery state in response to the secondary or spring brakes being in a released state. The control double check valve *108* also operates to isolate the service brake line *152* from the spring brake system.

[0032] While in the trailer spring brake pressurization state, the control valve *1 8 0* directs pressurized air at the supply port *1 81* to the delivery port *1 83*. Additionally, pressurized air at the spring brake delivery port *183* is applied to a trailer spring brake control valve pilot or control port *1 88*. Supply pressure at the pilot port *1 88* latches or holds the trailer spring brake control valve in position after the operator releases the plunger button *1 87*, thereby latching the trailer spring brake control valve *1 8 0* in the spring brake pressurization state.

[0033] When the operator desires to again park the vehicle and apply the tractor parking/spring brakes *107* and/or the trailer parking/spring brakes *1 84*, the operator actuates the plunger buttons *174, 187* to overcome forces associated with the spring brake pressure applied to the tractor spring brake control valve pilot port *176* and the spring brake pressure applied to the trailer brake control valve pilot port *188*. This returns the tractor and trailer spring brake control valves *160 , 180* to their exhaust states. Pressures at the tractor and trailer spring brake delivery ports *168 , 183* are vented to exhaust ports *166 , 182* and the spring brakes engage the wheels of the vehicle tractor and trailer. Additionally, pressure at the locking pressure port

116 is relieved. Therefore, pressure is relieved from the actuating pressure port *120* of the inlet valve *110*. The spring *126* then urges the inlet valve into a closed position, thereby preventing the release of the tractor parking brakes *107* and the trailer parking brakes *184* without a prior application of the service brakes *106*.

[0034] When the tractor and trailer spring brake control valves *160, 180* are placed in an exhaust state in order to vent or relieve pressure in the tractor and trailer spring brakes *107, 184*, pressurized air flows from the tractor spring brake exhaust port *166* and the trailer spring brake exhaust port *182* to atmosphere *178*. An exhaust conduit *190* carries the exhaust flow from the tractor spring brake exhaust port *166* to atmosphere *178*.

[0035] Having described the invention in general terms, details of an exemplary embodiment are now discussed. Referring to *FIGURES 2A and 2B*, a valve assembly *604* requires an operator of a vehicle to apply service brakes *606* of the vehicle before parking spring brakes *607* of the vehicle tractor and parking spring brakes *609* of the vehicle trailer are released. The valve assembly comprises a control double check valve *608* and an inlet valve *610*. The control double check valve *608* and inlet valve *610* reside in a common

housing *612*. The housing *612* includes a check valve chamber *614* and an inlet valve chamber *616*.

[0036] The control double check valve *608* includes a spacer *618*, a biasing spring *620*, and check valve member *622*. The spacer includes grooves *624* that carry seals such as o-rings *626*. The seals *626* divide the check valve chamber *614* into a first region *628* and a second region *630*. The spacer *618* includes a passage *632* that provides communication between the first region *628* and the second region *630*. Additionally, the spacer includes a first valve seat *634* operative to receive the check valve member *622*. As will be further described in reference to *FIGURES 3A and 3B*, a second region end *636* of the passage *632* is closed when the first valve seat *634* receives the check valve member *622*.

[0037] The spring *620* is located between the spacer *618* and the check valve member *622*, urging the check valve member *622* toward a second valve seat *638*. When seated on the second valve seat *638*, the check valve member *622* isolates the second region *630* from a service pressure port *640*.

[0038] The inlet valve *610* includes a valve frame *642*, a piston *644*, a piston spring *646*, a valve guide *648*, an inlet valve

member *650*, and an inlet valve member return spring *652*. The valve frame *642* includes a set of grooves *654* carrying associated seals *656* that divide the inlet valve chamber *616* into a third region *660*, fourth region *661*, and fifth region *662*. The valve frame *642* also includes a piston guide region *664* and an inlet valve seat *666*. The inlet valve seat *666* is located at a boundary between the fourth *661* and fifth *662* regions of the inlet valve chamber.

[0039] During inlet valve *610* operation, the inlet valve member is occasionally seated on the inlet valve seat *666*. During those times, the inlet valve member *650* and the inlet valve seat *666* form a seal separating the fourth *661* and fifth *662* inlet valve regions. When the inlet valve member *650* is not seated on the inlet valve seat *666*, there is free communication between the fourth *661* and fifth regions *662*. As will be explained in greater detail below, the valve frame *642* also includes various grooves, cutouts and passages that, either alone, or in cooperation with various inlet valve components, form passages or conduits for air flow.

[0040] The piston *644* has a piston head *668* and a shaft portion *669*. The piston head *668* and the shaft *669* each include grooves carrying seals *670* to maintain isolation between

the third and fourth inlet valve regions *660, 661*. The shaft *669* is slidably received in the piston guide region *664* of the frame *642*. The piston is urged toward the third region *660* by piston spring *646*. The piston spring *646* is mounted between an overhang portion of the piston head *668* and a piston spring support *674* portion of the inlet valve frame *642*. The piston shaft *669* includes a valve guide bore *676*. The valve guide bore *676* is located axially with respect to the piston shaft *669*.

[0041] The valve guide *648* is, for example, a pin. The valve guide *648* is received within the valve guide bore *676*. A portion of the valve guide *648* projects outwardly from the valve guide bore into the fifth region *662* of the inlet valve chamber *616*.

[0042] In one embodiment, the inlet valve member *650* is made of a resilient material such as rubber. The inlet valve *650* member includes a valve guide bore *677* axially located with respect to the inlet valve member *650*. The guide bore *677* receives a tip of the projecting portion of the valve guide *648* to axially locate the inlet valve member *650* within the fifth region *662* of the inlet valve chamber *616*.

[0043] The second region *630* of the control double check valve

608 communicates with the third region *660* of the inlet valve *610* through a second passage *679*. In addition to the control double check valve *608* and the inlet valve *610*, the first embodiment *604* further comprises a primary pressurized air source *680*, a secondary pressurized air source *681*, a source selection valve *682*, a service brake actuator or pedal *683*, a tractor spring brake control valve *684*, and a trailer air supply valve *685*.

[0044] The primary and secondary pressure sources *680, 681*, respectively, are each connected to the source selection valve *682* which directs air from one of the pressure sources to an inlet port *686* of the inlet valve *610* through a supply conduit *687*. The primary and secondary pressure sources are also each connected to the service brake actuator *683* through first and second service supply lines *689, 690*, respectively.

[0045] The service brake actuator *683* delivers proportioned pressure outputs to a second source selection valve *691* through first *689'* and second *690'* respective service actuator output lines. The pressures delivered in output lines *689', 690'* are related to both their respective supplies *680* , *681* and the position of the service brake actuator *683*. The second source selection valve *691* connects one of the

output lines *689', 690'* to a service brake line *692* based on the relative pressures of the airs contained within the output lines *689', 690'*. For example, the output line containing air at a higher pressure is directed to the service brake line *692*.

[0046] The service brake line delivers the selected output pressure to the service brakes *606* of the vehicle. Additionally a branch of the service brake line delivers the selected output pressure to a control inlet *693* of the control double check valve *608*. When the check valve member is not seated on the second valve seat *638*, the control inlet *693* communicates with the second region *630* of the control double check valve *608*.

[0047] An inlet valve outlet port *694* is connected to a tractor spring brake valve inlet port *695* of the tractor spring brake control valve *684* and a trailer valve inlet *688* of the trailer air supply valve *685* through an inlet valve output conduit *696*. The inlet valve outlet port *694* communicates with the fourth region *661* of the inlet valve *610*.

[0048] A tractor valve delivery port *697* is connected to a spring brake line *698*. A branch of the spring brake line *698* is connected to a lockout port *699* of the control double check valve. The lockout port *699* communicates with the

first region *628* of the control double check valve *608*.

[0049] As depicted in *FIGURES 2A and 2B*, the first embodiment *604* of a valve assembly is in a brake release prevention state. Supply pressure is available in the supply conduit *687*. Additionally, plunger buttons of the tractor spring brake control valve *684* and the trailer air supply valve *685* have been deactuated. Therefore, the tractor spring brake control valve *684* and the trailer air supply valve *685* are configured to deliver air to the tractor spring brakes *607* and the trailer spring brakes *609* for causing the spring brakes to release the wheels (not shown). However, the service brake actuator *683* has not been actuated and, therefore, no pressure is applied to the control input *693* of the control double check valve and no pressure is applied to the piston *644* to counteract the force of the spring *646*. Therefore, the piston is positioned toward the third region *660* and the inlet valve member *650* is seated on the inlet valve seat *666*.

[0050] Although supply pressure is available at the inlet valve inlet *686* and therefore in the fifth region, there is no communication between the fifth and fourth regions. Therefore, supply pressure is not available at the inlet valve outlet port *694* and no supply pressure is available at the

tractor spring brake valve inlet *695* or the trailer valve inlet *688*. Deprived of supply pressure, neither the tractor spring brake control valve *68 4* nor the trailer spring brake control valve *685* can deliver pressurized air to the spring brake line even though the valve is configured to do so. Therefore, the tractor spring brakes remain engaged and the vehicle is prevented from rolling unexpectedly.

[0051] Referring to *FIGURES 3A and 3B*, the valve assembly *704* illustrates a second operational state of the *FIGURES 2A and 2B* embodiment. In the second operational state, a tractor spring brake control valve *708* and a trailer spring brake control valve *707* are in respective spring brake exhaust configurations. A tractor valve button *710* and associated plunger *712* is actuated (lifted upwardly as shown), thereby directing pressurized air in spring brake line *714* connected at a spring brake delivery port *716* to an exhaust port (not shown). The tractor spring brakes *718* thus engage the wheels of a vehicle, thereby preventing the vehicle from rolling. Similarly, a trailer valve button *711* and associated plunger *713* is actuated (lifted upwardly as shown), thereby directing pressurized air in spring brake line *715* connected at a spring brake delivery port to an exhaust port (not shown). The trailer spring brakes *709*

thus engage the wheels of the vehicle, thereby preventing the vehicle from rolling.

[0052] Additionally, in the second operational state, service brake actuator/brake pedal *720* is actuated so that air in service brake line *722* is above a threshold pressure and the service brakes *724* engage the wheels (not shown) of the vehicle. The threshold pressure is selected so that the vehicle will not roll unexpectedly if the tractor spring brakes or the trailer spring brakes *718* , *709*, respectively, are released. Service pressure is also delivered to an input *726* of a control double check valve *728*. With the check valve member *730* unseated from valve seat *734*, the pressurized air at the control input *726* communicates with the second check valve region *742* and with a passage *744* between the second check valve region *742* and a third region *746* of an inlet valve *748*. A force arising from pressure applied to the piston overcomes a force of a piston spring *752* so that the piston moves toward a fourth region *754* of the inlet valve. Valve guide *756* moves with the piston *750* and an inlet valve member *757* associated with the valve guide. Both the valve guide *756* and inlet valve member *757* are moved further into a fifth region *758* that communicates with an inlet valve supply port *759*. The fourth region *754*

communicates with an inlet valve outlet port *760*. As a result of movement of the inlet valve member from an inlet valve seat *762*, a communication path is opened between the fourth and fifth inlet valve regions. Pressurized air delivered to the inlet valve inlet port *759* is communicated to the fourth region *754* by the communication path that was opened when the inlet valve member *757* was lifted off the inlet valve seat *762*. As described above, the inlet valve outlet port *760* communicates with the fourth region *754*. Therefore, the inlet valve outlet port *760* also receives pressurized air which is made available to a tractor spring brake control valve inlet port *770* and a trailer spring brake control valve inlet port through an inlet valve output conduit *771*. If the tractor valve button *710* (and associated plunger *712*) or the trailer valve button *711* (and associated plunger *713*) were deactuated (e.g., pushed down), the tractor spring brake control valve *708* and the trailer spring brake control valve would deliver pressurized air for releasing the spring brakes *718* , *709*, respectively.

[0053] Referring to *FIGURES 4A and 4B*, the valve assembly (now referenced as numeral *804*) is shown in a third operational state. In the third operational state, the service brake pedal *808* has been actuated beyond a threshold degree so

that supply pressure is available at a tractor valve inlet port *810* of a tractor spring brake control valve *812*. However, in the third state, tractor valve button *814* and a tractor valve plunger *816* are deactuated while trailer valve button *811* and a trailer valve plunger *813* are actuated. As is explained in greater detail in the U.S. Patent 4,844,553 to Bliss, previously incorporated by reference, depressing the valve button *814* and plunger *816* directs pressurized air available at the inlet port *810* to a tractor spring brake control valve delivery port *818* and to tractor spring brakes *820* through a spring brake line *822*, thereby releasing the tractor spring brakes. Since the trailer valve button *811* and plunger *813* are actuated, the trailer spring brakes *809* are engaged. A branch of the spring brake line also delivers pressurized air to a lockout port *824* of a control double check valve *826*. The lockout port *824* communicates with a first region *828* of the control double check valve *826*. A passage *829* in spacer *830* conducts pressurized air in the first region *828* to a second region *834* of the passage *828*, urging check valve member *836* away from a first check valve seat *838* and against a second check valve seat *840*.

[0054] The pressurized air in the passage *829* acting downwardly

(relative to the FIGURE) on the check valve member *836* is higher than or equal to a pressure of pressurized air acting upwardly (relative to the FIGURE) on the check valve member *836* and, therefore, the check valve member is pressed against the second seating surface *840* thereby sealing off the control input. The check valve member *836* is moved away from the first seating surface and pressurized air flows through the passage into a third region *842* of the control double check valve and into a second passage *848* that communicates with a fourth region *850* of an inlet valve *852*. This provides a force acting on piston *856* of the inlet valve *852* and, in this way, spring brake line pressure *822* delivered to the lockout port *824* latches the inlet valve *852* in an open position independent of the degree of actuation of the service brake actuator *808*. This allows the tractor spring brakes to be maintained in their released state after a vehicle operator, for example, removes his foot from a service brake pedal *808*.

[0055] Referring to *FIGURES 5A and 5B*, the valve assembly *904* is in a fourth operational state. The fourth operational state is similar to the third operational state of *FIGURES 4A and 4B*; however, the service brake pedal *908* is not actuated. Nevertheless, pressure in spring brake line *910* is delivered to

a lockout port *912* and serves to hold an inlet valve *914* in an open position. Therefore supply pressure continues to be delivered to a tractor spring brake control valve inlet *916* of a tractor spring brake control valve *918* and a trailer spring brake control valve inlet *942* of a trailer spring brake control valve *940*. A plunger *920* (and button *922*) of the tractor spring brake control valve *918* and a plunger *913* (and button *911*) of the trailer spring brake control valve *940* are maintained in a deactuated (depressed) position (relative to the FIGURE). For example, internal to the tractor spring brake control valve *918* the pressure of the air applied to the inlet *916* overcomes the force generated by a tractor valve return spring *924* and holds the plunger *920* in the depressed position. Therefore, supply pressure continues to be delivered to the spring brake line *910*, spring brakes *926* and the lockout port *912*. Additionally, supply pressure at the inlet *916* is also delivered to an inlet *942* of the trailer supply valve inlet *942*. The pressure at the inlet *942* holds a plunger *944* of the trailer supply valve *940* in the depressed position. The trailer supply valve *940* delivers supply pressure to trailer systems, including, for example, trailer spring brakes (not shown). In one embodiment, a tractor protection valve *946* is included between

the trailer supply valve *940* and the trailer. With pressure supplied to the trailer, parking brakes of the trailer are released and the combination vehicle (tractor and trailer) can be driven to its destination.

[0056] Referring to *FIGURES 6A and 6B*, the valve assembly is shown in a fifth operational state which is actually a transition from the fourth operational state to the first operational state. In the fifth operational state plunger buttons *1006*, *1008* and plungers *1010*, *1012* of the tractor spring brake control valve *1014* and a trailer supply valve *1016* have been actuated (i.e., lifted). Therefore the valves *1014*, *1016* are in an exhaust position where pressurized air from spring brakes *1018* and spring brake line *1020* is vented through a tractor spring brake control valve exhaust port *1022*. Likewise, pressurized air from a trailer system (not shown) and trailer supply line *1024* is vented through a trailer supply valve exhaust port *1026*.

[0057] Additionally, in the fifth operational state, a service brake actuator *1028* is not actuated so that air pressure in service brake line *1030* is zero. For example, the pressure of air in the service brake line is below a threshold thereby indicating that the service brakes are not engaged sufficiently to prevent the vehicle from rolling unexpectedly.

As the spring brakes *1018* and spring brake line *1020* are vented, pressurized air in a first region *1032* of a control double check valve *1034* flows from a lockout port *1036* of the control double check valve *1034* and into the spring brake line *1020* to be vented to atmosphere. As air leaves the first region *1032*, air in a second region *1038* of the control double check valve *1034* flows through a first passage *1040* into the first region *1032* and out the lockout port *1036*. Therefore, a pressure in the second region *1038* is reduced. Similarly, air in a third region *1042* of an inlet valve assembly *1044* flows through a second passage *1046* into the second region *1038* and eventually out the lockout port *1036*. As pressurized air leaves the third region *1042*, a piston spring or resilient member *1048* is able to urge a piston *1050* of the inlet valve assembly *1044* toward the third region *1042*. As the piston *1050* moves toward the third region *1042*, forces from an inlet valve member return spring *1052* and/or pressurized air supplied from an inlet port *1054* of the inlet valve assembly *1044* urge an inlet valve member *1056* and an associated valve *1058* guide toward and further into a fourth region *1060* of the inlet valve assembly *1044*, respectively. Ultimately, the inlet valve member *1056* is seated on an inlet valve seat *1062*

thereby preventing communication between the fifth region *1064* and the fourth region *1060*. Therefore, no significant amount of pressurized air is available to the tractor spring brake valve inlet port *1070* or the trailer spring brake valve inlet port. When substantially all the pressurized air has been vented or returned to a low pressure tank or reservoir, the transition is complete and the fifth valve assembly *1004* is in the first operational state.

[0058] Referring to *FIGURE 7*, a closed inlet valve assembly *1304* preferably includes a venting means *1308* operative to vent air from a fourth region *1312* of the closed inlet valve assembly *1304*. A piston *1314* is positioned in a right-most piston position so that a third region *1316* of the inlet valve assembly *1304* is at a minimum size. An inlet valve member return spring *1320* urges an inlet valve member *1322* and a valve guide *1324* into a right-most position. The inlet valve member *1322* is seated on valve seat *1330*. Therefore, communication between a fifth region *1334* and the fourth region *1312* of the inlet valve assembly *1304* is prevented. Typically, the inlet valve assembly *1304* assumes the closed state when an operator of a vehicle switches the tractor spring brake control valve *160*, *684*, *1216* from a spring brake release state into a spring brake

exhaust state. This operation tends to trap pressurized air in the fourth region *1312* of the inlet valve assembly *1304* and in an inlet valve output conduit or passage *162*, *696* (see *FIGURES 1, 2A, and 2B*).

[0059] This trapped air can affect the operation, sound and feel of the tractor spring brake control valve when the operator next attempts to release the spring brakes. For example, as the tractor spring brake control valve is moved from the exhaust state to the spring brake release state, trapped air would flow from the fourth region *1312* and associated passages into the spring brake line. As the air is delivered, an audible sound is emitted even if the primary and secondary pressure reservoirs are empty. In this case, the sound may confuse the operator into believing the spring brakes are released, when, in fact, they are still engaged. Additionally, the trapped air resists the operator's actuation of the tractor spring brake control valve. For example, the operator must compress the trapped air in order to move the tractor spring brake control valve into the spring brake release state. For the forgoing reasons, the inlet valve assembly *1304* preferably includes the venting means *1308*.

[0060] For example, the venting means includes a vent seat *1340*.

The vent seat *1340* is operative to receive the inlet valve member *1322* when the inlet valve is in an open state. However, in the illustrated closed state, the inlet valve member *1322* is not seated on the vent seat *1340*. When the piston *1314* is in the illustrated right-most position, the inlet valve seat *1330* serves to separate the inlet valve member *1322* from the vent seat *1340*. The vent seat *1340* is at an inlet valve member end of an axial bore *1342* in a shaft portion *1344* of the piston *1314*. The bore *1342* is operative to slidably receive the valve guide *1324*. Additionally, a gap *1346* between the valve guide *1324* and a wall *1348* of the bore is operative as a first portion of a piston vent passage *1350* in the piston *1314*. When the inlet valve assembly *1304* is in the illustrated closed state, the vent seat *1340* is positioned in the fourth region *1312*. The piston vent passage *1350* is in communication with a frame vent passage *1352*. The frame vent passage *1352* communicates with a vent region *1353*, e.g., atmosphere.

[0061] When the inlet valve member *1322* is not seated on the vent seat, as shown in *FIGURE 7*, the fourth region *1312* is in communication with the piston vent passage *1342* through the open vent seat *1340*, the piston vent passage *1350*, and in turn with the frame vent passage *1354* and

the vent region *1353*. When the inlet valve assembly *1304* is in the closed state, the venting means *1308* is in an open state. Therefore, air that would otherwise be trapped in the fourth region *1312* and associated passages when the inlet valve is closed is instead vented. Of course, the venting means *1308* must be sealed or closed when the inlet valve assembly *1304* is in an opened state.

[0062] Referring to *FIGURE 8*, an open inlet valve assembly *1404* includes a sealed venting means *1408*. A piston *1414* is positioned so that a third region *1416* of the inlet valve assembly *1404* is at a maximum size. Inlet valve member *1422* is unseated from inlet valve seat *1430* to form a communication path *1432* between fourth region *1436* and fifth region *1434*. Typically, the inlet valve assembly *1404* is urged toward an open state when an operator of a vehicle actuates a service brake actuator *154*, *683* in preparation to release parking spring brakes of a vehicle. This delivers pressurized air to the third region *1416* of the inlet valve assembly *1404* and drives the piston *1414* to the illustrated left-most position. As a result, the inlet valve member is urged against a vent seat *1444* portion of the piston *1414*. Additionally, pressurized air in the fifth region *1434* also urges the inlet valve member against the vent seat *1444*.

Therefore, pressurized air is prevented from leaking out through the venting means *1408* while the inlet valve assembly *1404* is in the open state.

[0063] Referring to *FIGURE 9*, the inlet valve assembly *1304*, *1404* of *FIGURES 7 and 8* may be included in any of the valve assembly embodiments described herein. The third valve assembly *1504* includes in a single housing *1508*, a tractor spring brake control valve *1510*, a trailer supply valve *1512*, a supply selector *1514*, a control double check valve *1516*, and an inlet valve *1518*.

[0064] As described previously, the supply selector *1514* communicates with primary and secondary supply input ports *1521, 1522*. Typically the primary and secondary supply ports are connected to primary and secondary pressurized air reservoirs (not shown). A selector check valve member *1524* of the supply selector *1514* moves to direct one of the primary and secondary supplies to a supply passage *1525*. For example, the supply delivering pressurized air at the highest pressure is directed to the supply passage *1525*.

[0065] The supply passage *1525* delivers pressurized air to an inlet or fifth region *1526* of the inlet valve *1518*.

[0066] The control double check valve *1516* communicates with a control input port *1530*, a control check valve output pas-

sage *1531* and a lockout passage *1532*. As previously described, in a first mode of operation, a control check valve member *1533* within the control double check valve *1516* moves to direct one of pressurized air delivered to the control input port *1530* and pressurized air delivered to the lockout passage *1532* to the control check valve output passage *1531*. For example, the port *1530* or passage *1532* carrying pressurized air at the highest pressure is directed to the control check valve output passage *1531*. In a second mode of operation, pressurized air in the control check valve output passage *1531* is vented through the lockout passage *1532*. The control check valve output passage *1531* merges into a third, or actuation region or piston, or control port *1534* of the inlet valve *1518*. The lockout passage *1532* is in communication with a seventh region *1536* of the tractor spring brake control valve *1510*.

[0067] The tractor and trailer spring brake control valves *1510* , *1512*, respectively, communicate with other devices through tractor and trailer valve input ports *1538* , *1528*, respectively, a spring brake delivery port *1540*, and a first exhaust passage *1542*. The tractor and trailer valve input ports *1538* , *1528* receive pressurized air from a fourth inlet valve region *1544* through an inlet valve output passage

1546. Of course, the tractor and trailer valve input ports *1538* , *1528* only receive pressurized air when the inlet valve *1518* is open. Of course, as previously described in reference to other figures, the inlet valve *1518* is only open when pressurized air directed to the third region or piston port *1534* by the control double check valve *1516* from the control port *1530* or the lockout passage *1532* are of sufficient pressure to hold the inlet valve *1518* open.

[0068] When the tractor spring brake control valve *1510* is pulled upward (actuated) (relative to the figure) into an exhaust state, as depicted in *FIGURE 9*, any pressurized air delivered to the tractor valve input port *1538* will pressurize a tractor valve plunger passage *1548*. However, the pressurized air from the tractor valve input port *1538* can travel no further, since distal ends *1550* of the plunger passage *1548* are isolated by plunger seals *1551* from any other region or passage. Additionally, when the tractor spring brake control valve *1510* is in the illustrated exhaust state, air in the lockout passage *1532* and the spring brake delivery port *1540* are placed in communication with, and flow out through, the first exhaust passage *1542* through an eighth region *1552* of the tractor spring brake control valve *1510*.

[0069] When the tractor spring brake control valve *1510* is pushed downward (deactuated) (relative to the figure) into a delivery state, the distal ends *1550* of the plunger passage are placed in communication with the seventh region *1536* of the tractor spring brake control valve *1510*. Therefore, pressurized air delivered to the tractor valve input port *1538* is placed in communication with the lockout passage *1532* and with the spring brake delivery port *1540*. Pressurized air in the seventh region *1536* works on a tractor valve seal *1556*. The pressurized air provides a force that overcomes a spring force of a tractor valve spring *1554*. Therefore, when the tractor spring brake control valve *1510* is placed in the delivery state and the seventh region is filled with pressurized air, the pressurized air serves to hold or latch the tractor spring brake control valve *1510* in the delivery state. In the depressed position (not shown), or deliver state, the tractor valve seal *1556* is seated on a tractor valve seat *1557*. In this position the tractor valve seal *1556* prevents communication between the first exhaust passage *1542* and the seventh *1536* or eighth *1552* tractor valve regions.

[0070] The trailer supply valve *1512* operates in a similar manner. The trailer supply valve *1512* communicates with other de-

vices through the trailer valve input port *1528*, a trailer delivery port *1562*, a reset passage *1564* or sampling point and, through the reset passage with an exhaust port *1565*. As mentioned above, the trailer valve input port *1528* receives pressurized air from the inlet valve output passage *1546*.

[0071] When the trailer supply valve *1512* is pulled upward (actuated) (relative to the figure), into an exhaust state, as depicted in *FIGURE 9*, any pressurized air delivered to the trailer valve input port *1528* pressurizes a trailer valve plunger passage *1566*. However, the pressurized air from the trailer valve input port *1560* can travel no further since distal ends *1567* of the plunger passage *1566* are isolated by plunger seals *1568* from any other region or passage. Additionally, when the trailer supply *1512* is in the illustrated exhaust state, air in the trailer delivery port *1562* passes through a tenth region *1570* of the trailer supply valve *1512*, through the trailer supply valve reset passage *1564* and is vented or exhausted through the exhaust port *1565*.

[0072] When the trailer supply valve *1512* is pushed downward (relative to the figure) into a delivery state, the distal ends *1567* of the plunger passage *1566* are placed in communi-

cation with a ninth region *1572* of the trailer supply valve *1512*. Therefore, pressurized air delivered to the trailer valve input port *1528* is placed in communication with the trailer delivery port *1562*. Pressurized air in the ninth region *1572* works on trailer valve seal *1576*, providing a force that overcomes a spring force of a trailer valve spring *1575*. Therefore the trailer supply valve *1512* is held or latched in a depressed or delivery state. In the delivery state (not shown) a trailer valve seal *1576* is seated on a trailer valve seat *1577*. In this position the trailer valve seal *1576* prevents communication between the trailer supply valve reset passage *1564* and the ninth *1572* or tenth *1570* tractor valve regions.

[0073] Of course, pressurized air delivered to the trailer delivery port *1562* flows out of the valve assembly. Typically the trailer system (not shown) is connected to the trailer delivery port *1562*. Therefore, when the trailer valve plunger is in the depressed position, pressurized air flows from the supply selector *1514*, through the inlet valve *1518*, the inlet valve output passage *1546*, and the trailer plunger passage *1566* into the ninth region *1572*, out the trailer delivery port *1562* and into the trailer system.

[0074] Of course, at low system pressures, the force working on

the trailer valve seal *1576* falls below a threshold and the trailer valve spring forces the trailer supply valve *1512* into the exhaust state, thereby applying the brakes of any attached trailer.

[0075] In addition to the low pressure auto exhaust feature just described, the trailer supply valve *1512* can also be automatically driven into the exhaust state by exhaust air from the tractor spring brake control valve *1510*. When the tractor spring brake control valve *1510* is switched or moved into the exhaust state, pressurized air from a spring brake line (not shown) attached to the spring brake delivery port *1540* is directed to the first exhaust passage *1542* through the tractor spring brake control valve *1510*. As the air flows toward the exhaust port *1565*, reset port *1564* is also pressurized. If the trailer supply valve *1512* is in the delivery state when tractor spring brake control valve *1510* exhaust air pressurizes the reset port, then a force generated by the pressure in the reset port is added to a force delivered by the trailer valve spring *1575*. The combined forces overcome the force generated by pressurized air in the tenth region *1570* applied to the trailer valve seal *1576*. Therefore, the trailer supply valve *1512* is automatically switched into the exhaust state.

[0076] While the present invention has been illustrated by the description of embodiments thereof, and while the embodiments have been described in considerable detail, it is not the intention of the applicants to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. Therefore, the invention, in its broader aspects, is not limited to the specific details, the representative apparatus, and illustrative examples shown and described. Accordingly, departures may be made from such details without departing from the spirit or scope of the applicant's general inventive concept.